

ECE 351 Lab 10

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Introduction

In this lab we will be working with a filter to modify a signal. As the signal is modified through the filter, both its magnitude and its phase angle will be affected, and so both of those need to be accounted for. To track its impact we can graph the relationship between incoming frequencies and the filters effect on it. We can do this by hand, like in the pre lab document or we can use python's libraries to calculate the bode plots of a filter with a given transfer function. Once we have the bode plots plotted, we can use a sample signal to test its effect.

Math

In this section we can insert the math done in the pre lab procedures:

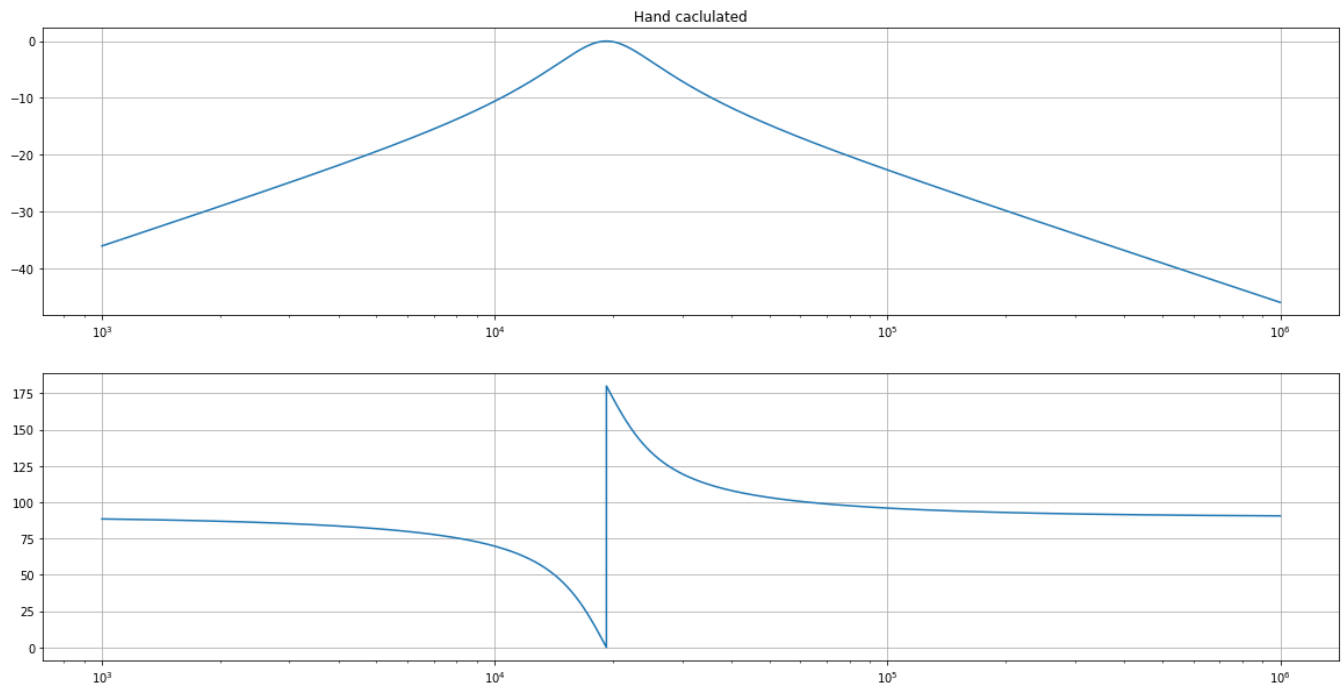
$$\begin{aligned}H(s) &= \frac{\frac{1}{RC}s}{s^2 + \frac{1}{RC}s + \frac{1}{LC}} \\g &= \frac{1}{RC}s \Big|_{-s=p} \\p &= -\frac{\frac{1}{RC}}{2} \pm \frac{\sqrt{\frac{1}{(RC)^2} - 4(\frac{1}{LC})}}{2} \\g &= \frac{1}{RC}(-\frac{\frac{1}{RC}}{2} \pm \frac{\sqrt{\frac{1}{(RC)^2} - 4(\frac{1}{LC})}}{2}) \\|g| &= \sqrt{\left(-\frac{1}{2(RC)^2}\right)^2 + \left(\frac{\sqrt{\frac{1}{(RC)^2} - 4(\frac{1}{LC})}}{2RC}\right)^2} \\\angle g &= \tan^{-1}\left(\frac{\frac{\sqrt{\frac{1}{(RC)^2} - 4(\frac{1}{LC})}}{2RC}}{\frac{1}{(RC)^2}}\right)\end{aligned}$$

But for the actual lab we can plug in values of the components which are given as:

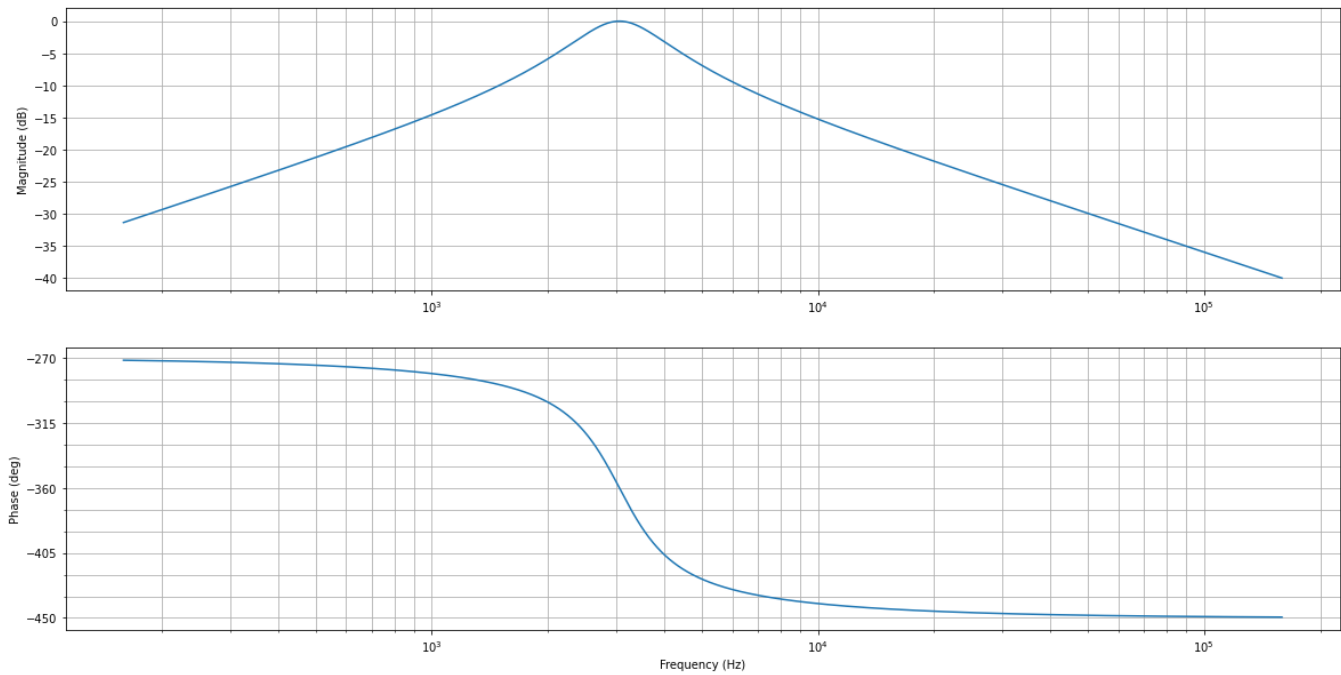
$$L = 27mH, C = 100nF, R = 1000\Omega$$

Graphs

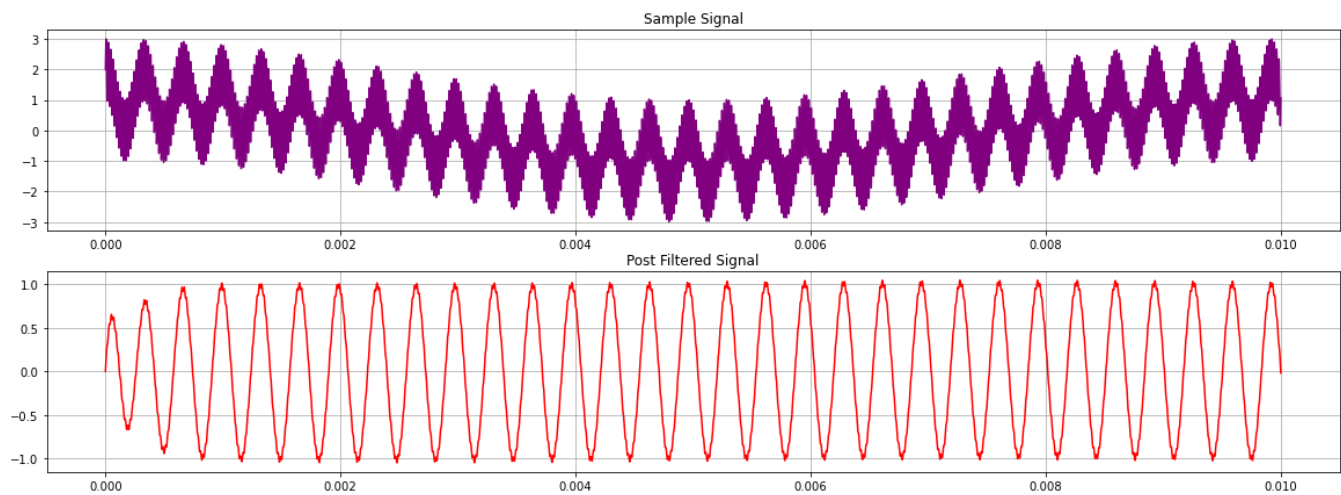
Using the math and values above, we can plot in python the transfer function bode plots:



If we use the built in functions we produce the following graph:



The last thing to do is to run a signal through this filter to see what happens:



Questions

1. Explain how the filter and filtered output in Part 2 makes sense given the Bode plots from Part 1. Discuss how the filter modifies specific frequency bands, in Hz.

Given the bode plot, we have a narrow range band-pass filter. The input signal is comprised of many frequencies, and the output looks like a single frequency. This makes sense as the filter only allowed through the single frequency in the pass-band.

2. Discuss the purpose and workings of `scipy.signal.bilinear()` and `scipy.signal.lfilter()`.

The `bilinear` function takes a transfer function and converts into the z domain, and the `lfilter` function is used to filter a function through the filter using the given z domain transfer function.

3. What happens if you use a different sampling frequency in `scipy.signal.bilinear()` than you used for the time-domain signal?

The time domain signal resolution is related to the sampling frequency, so if the frequency increased then so would the time domain function resolution, with the opposite also being true.

Conclusion

In this lab we were able to create a transfer function from a given circuit. Using that transfer function we were then able to transform it to the z domain and use that to filter a signal through it. This process makes filtering a signal much faster and easier than trying to convolve the transfer function with the signal as the signal is not apparently a regular signal. This allows us to check the functionality of our band pass filter easily.